

Claims

- 5 1. A positioning system for one or more cables towed underwater behind a marine vessel, the positioning system comprising:
- at least two surface units traveling with a marine vessel at the water surface, each surface unit including:
- 10 a GPS receiver for receiving radio-frequency GPS signals and determining the position of the surface unit; and
- an acoustic transmitter for transmitting into the water acoustic message signals representing the position of the surface unit;
- a plurality of acoustic receiver units disposed underwater along one or more cables towed underwater behind the marine vessel, each cable extending from a head end nearer the
- 15 marine vessel to an opposite tail end, each acoustic receiver unit including:
- an acoustic receiver for receiving the acoustic message signals transmitted by the plurality of surface units and determining the position of the acoustic receiver unit from the acoustic message signals.
2. A positioning system as in claim 1 further comprising:
- 20 an acoustic transceiver unit attached to one of the cables and including:
- an acoustic receiver for receiving the acoustic message signals transmitted by the plurality of surface units and determining its position from the acoustic message signals; and
- an acoustic transmitter for transmitting into the water acoustic message signals
- 25 representing its position, and
- wherein the acoustic receivers in at least some of the acoustic receiver units receive the acoustic message signals from the acoustic transceiver unit for use in determining position.
3. A positioning system as in claim 1 comprising four surface units, two of the surface units towed on opposite sides of the marine vessel near the head end of the cable and two of the surface units towed
- 30 spaced apart near the tail end of the cable.
4. A positioning system as in claim 2 having a plurality of cables towed behind the marine vessel and wherein the surface units are towed near the head end and the tail end of the cable and comprising a plurality of acoustic transceiver units disposed between the head end and the middle and the tail end and the middle of the outermost towed cables.
- 35 5. A positioning system as in claim 1 further comprising a communication link between the marine vessel and the acoustic receiver units over which position data from the acoustic receiver units are transmitted to the marine vessel.

6. A positioning system as in claim 1 further comprising a two-way communication link between the marine vessel and the surface units and the acoustic receiver units.
7. A positioning system as in claim 1 comprising at least three surface units and wherein each acoustic receiver receives acoustic message signals transmitted from three surface units.
- 5 8. A positioning system as in claim 1 wherein the acoustic message signal includes a time stamp.
9. A positioning system as in claim 8 wherein the time stamp is a sequence number.
10. A positioning system as in claim 1 further comprising a communication link between the marine vessel and the acoustic receiver units over which a clock-synchronizing signal is sent to the acoustic receiver units.
- 10 11. A positioning system as in claim 1 wherein the GPS receiver in the surface units recovers GPS time from the radio-frequency GPS signals and wherein the surface units further include a clock synchronized to GPS time, the clock determining the time of transmission of the acoustic message signals.
12. A positioning system as in claim 1 further comprising a cable control device associated with the acoustic receiver unit and using the position determined by the acoustic receiver unit to control the cable.
- 15 13. A positioning system as in claim 1 wherein at least one of the surface units is housed in marine survey equipment selected from the group consisting of: paravanes, tail buoys, and remote-controlled, autonomous surface vehicles.
- 20 14. A method for positioning underwater streamer cables towed behind a surface vessel in a marine seismic survey, comprising:
- attaching acoustic receiver units at spaced apart locations on one or more streamer cables;
- towing the streamer cables underwater behind a surface vessel;
- towing a plurality of surface units including GPS receivers and acoustic transmitters behind the
- 25 surface vessel;
- receiving GPS signals in the surface units;
- transmitting acoustic message signals from each of the surface units representing the surface unit's position;
- receiving the acoustic message signals in the acoustic receiver units to determine the positions
- 30 of the acoustic receiver units.
15. The method as in claim 14 further comprising:
- sending a clock-synchronizing signal to the acoustic receiver units.
16. The method as in claim 14 further comprising:
- recovering GPS time from the GPS signals received in the surface units to synchronize the
- 35 transmitting of the acoustic message signals to GPS time.
17. The method as in claim 14 further comprising:
- attaching acoustic transceiver units including acoustic receivers and acoustic transmitters at locations on one or more of the streamer cables;

receiving the acoustic message signals transmitted by the surface units in the acoustic transceiver units;

transmitting acoustic message signals from each of the acoustic transceiver units representing the acoustic transceiver unit's position; and

receiving the acoustic message signals transmitted by the acoustic transceiver units in the acoustic receiver units to determine the positions of the acoustic receiver units.

18. The method as in claim 17 further comprising:

sending a clock-synchronizing signal to the acoustic receiver units and the acoustic transceiver units.

19. The method as in claim 14 further comprising:

controlling the position of the underwater cables from the positions determined by the acoustic receiver units.

20. A positioning system for one or more cables towed, or dragged, underwater behind a marine vessel, the positioning system comprising:

at least two surface units traveling with a marine vessel along the water surface, each surface unit including:

a GPS receiver for receiving radio-frequency GPS signals; and

an acoustic transmitter for transmitting into the water coded signals identifying the particular surface unit;

a plurality of acoustic receiver units disposed underwater along one or more cables towed underwater behind the marine vessel, each cable extending from a head end nearer the marine vessel to an opposite tail end, each acoustic receiver unit including:

an acoustic receiver for receiving the coded signals transmitted by the plurality of surface units and determining the code delay of the coded signals so that the position of the acoustic receiver unit can be determined.

21. A positioning system as in claim 20 further comprising:

a navigation system aboard the marine vessel;

a communication link between the navigation system and the acoustic receiver units,

wherein the acoustic receiver units transmit pseudorange data indicative of the code delay of

the coded signals to the navigation system to determine the positions of the acoustic receiver units.

22. A positioning system as in claim 21 wherein the navigation system transmits a clock-synchronizing signal over the communication link to the acoustic receiver units.

23. A positioning system as in claim 21 further comprising a cable control device associated with and

proximate to each acoustic receiver unit and wherein the navigation system transmits a command signals over the communication link to the cable control device to control the position of the cable.

23. A positioning system as in claim 20 wherein the acoustic transmitter in each surface unit transmits telemetry data indicative of the surface unit's position with the coded signals to the acoustic receiver units.

24. A positioning system as in claim 20 wherein the GPS receiver in the surface units recovers GPS time from the radio-frequency GPS signals received in the surface units to synchronize the transmitting of the coded signals to GPS time.

25. A positioning system as in claim 20 wherein at least one of the surface units is housed in marine survey equipment selected from the group consisting of: paravanes, tail buoys, and remote-controlled, autonomous surface vehicles.